5.10 RING IMAGING CERENKOV COUNTER (RICH)

The RICH is located near the bottom of the experiment stack, below the Lower TOF and above the ECAL. The RICH is used in conjunction with the Silicon Tracker to establish the mass of particles that traverse the AMS-02. The function of the Silicon Tracker is capable of establishing the momentum of the particle with a relative accuracy of approximately 1%. The RICH is able to determine the velocity of charged particles based on the Cerenkov Effect as the particle passes through the mass of the silica aerogel or sodium fluoride blocks. Cerenkov radiation is emitted as a charged particle passes through a transparent non-conducting material at a speed greater than the speed of light in that material. The use of a high efficiency reflector ring allows for greater data acquisition than direct incident of the photons on the PMTs alone.

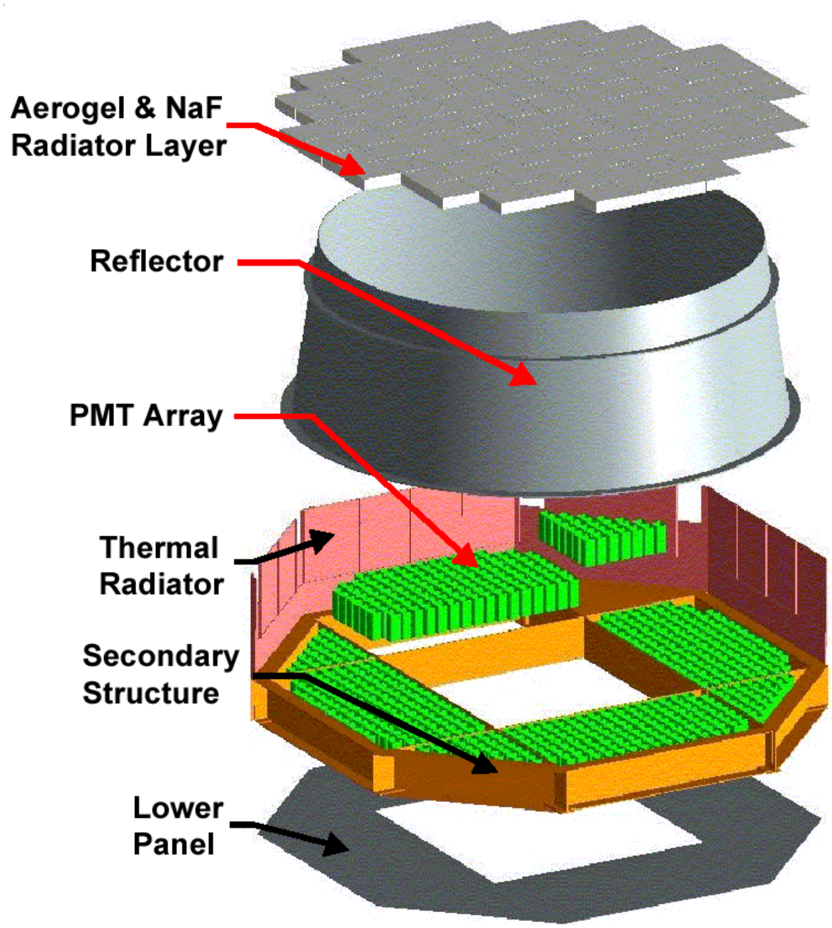

Figure 5.10-1 RICH Basic Elements

Functionally the RICH is composed of three basic elements, the top layer, the Cerenkov radiator, is composed of silica aerogel and sodium fluoride (NaF) blocks that serve as sources for the Cerenkov radiation generated by the passage of the high energy particles. The intermediate layer is the conical mirror and the lower the PMT and structural interfaces.

In the top layer the aerogel and NaF blocks are mounted between a PORON spacer and carpet and a PMMA cover, all supported by a carbon fiber reinforced composite (CFRC) structure. The entire structure is sealed with a viton gasket between the PMMA cover and the composite structure. The PMMA cover allows the photons generated by the passage of the high-energy particles to be observed by the photomultipliers.

Figures 5.10-2, 5.10-3 and 5.10-4 show the general construction of the assembly. Polymethylmethacrylate (PMMA, Acrylic, Plexiglas) is used to contain the aerogel and crystalline NaF blocks and allow the photons to enter the zone of the conical mirror and the PMTs.

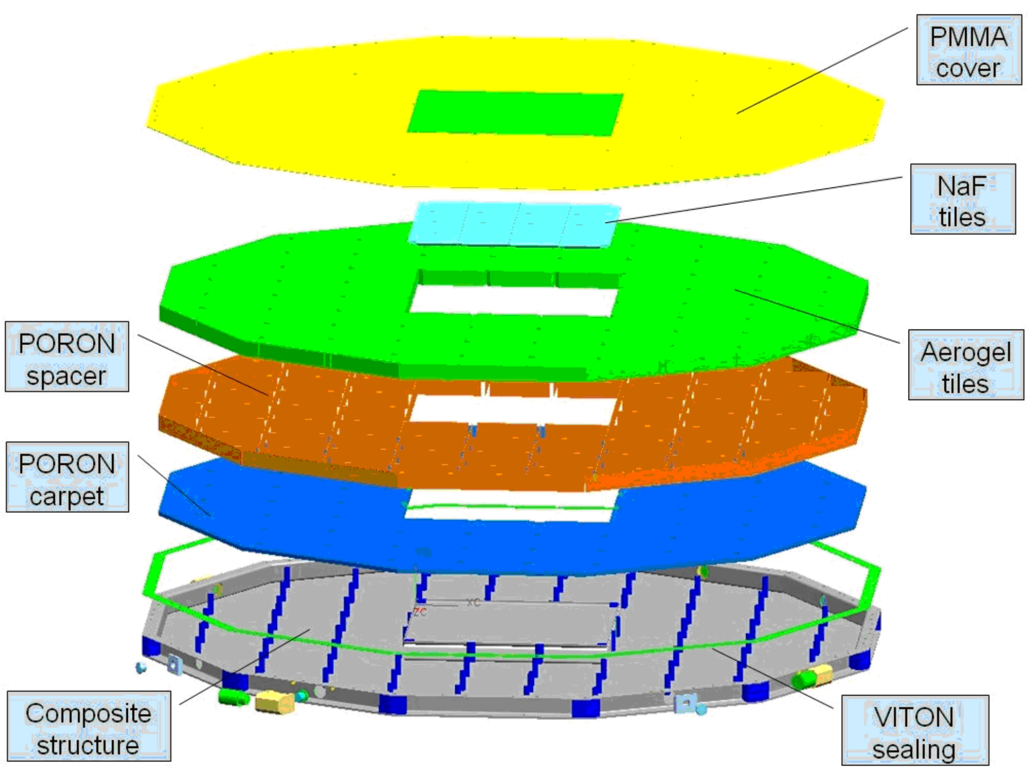

Figure 5.10-2 RICH Aerogel & NaF Container

The RICH upper assembly of aerogel and NaF blocks is vented during ascent by four vent valves and during descent repressurization is controlled by three vent valves. In order to protect this volume once constructed it will be purged through a dedicated valve port with dry nitrogen to provide a clean controlled environment within the Cerenkov Radiator. 50 μm filter screens on the valves will prevent large aerogel or NaF particles that could possible evolve from being released or exterior contaminants becoming ingested. The locations of these valves are shown in Figures 5.10-3 and 5.10-4 and a cross section of the selected breather valve is shown in Figure 5.10-6. These valves will be Halkey Roberts C770RP 1.0 one way valves that have a cracking pressure with a 1 psi differential. The valves will be interfaced to the 50 μm filter screens through a polyetheretherketone (PEEK) interface block as shown in Figure 5.10-7. During ground handling/transportation and processing this interior volume is protected from thermal and atmospheric pressure variation introducing humidity into the interior of the Cerenkov Radiator by having a buffer volume contained within an expandable reservoir (0.5 1) made of Teflon®/Tedlar® supported within a vented enclosure. This expandable reservoir is represented in Figures 5.10-5 and 5.10-8 a-c. Design of this assembly assures that there will not be more than a 1 psi differential between the interior and exterior pressure. Reentry loads of pressure loading on the aerogel during repressurization have been conservatively established to be approximately 1/15th of aerogel compression allowable. The aerogel is considered the most sensitive element of the sandwich of materials.

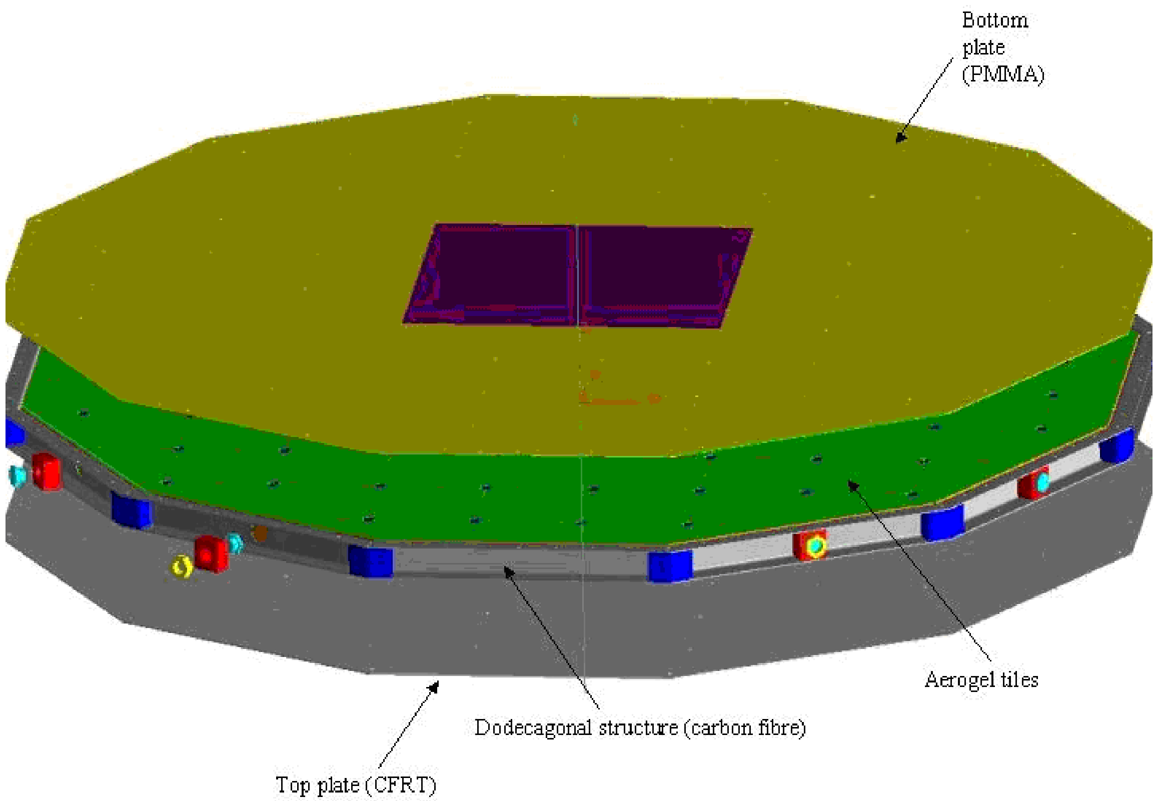

Figure 5.10-3 RICH Aerogel and NaF Assembly

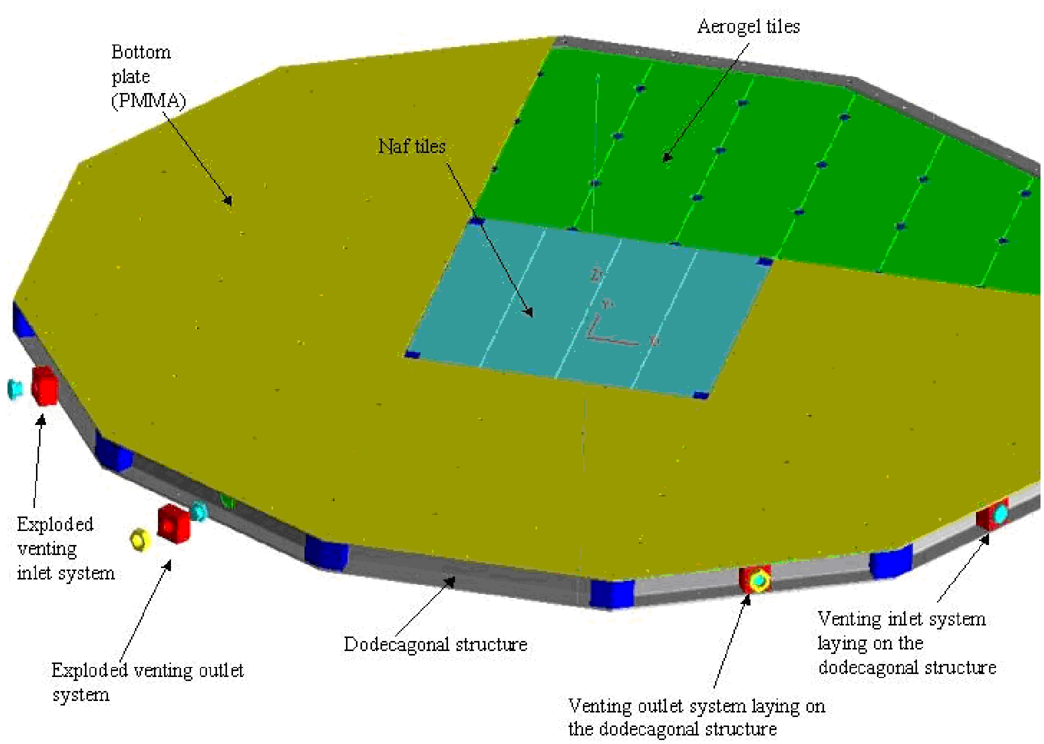

Figure 5.10-4 RICH Aerogel and NaF Assembly
(Vent interface updated in Figure 5.10-7)

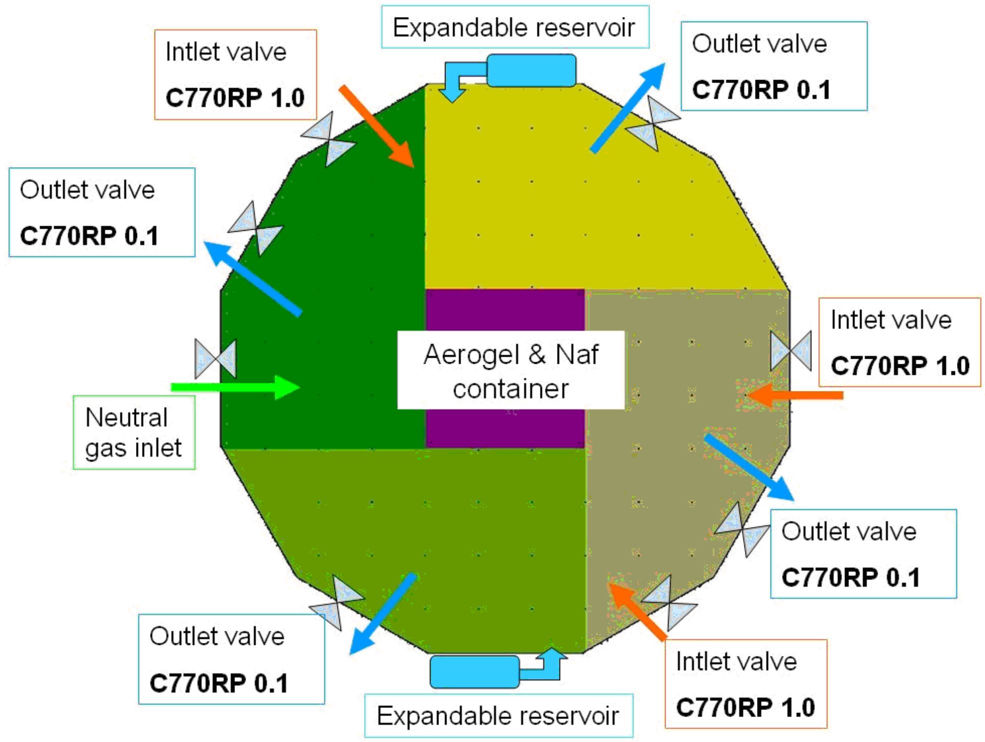

Figure 5.10-5 RICH Functional Venting, Interior Environment Control

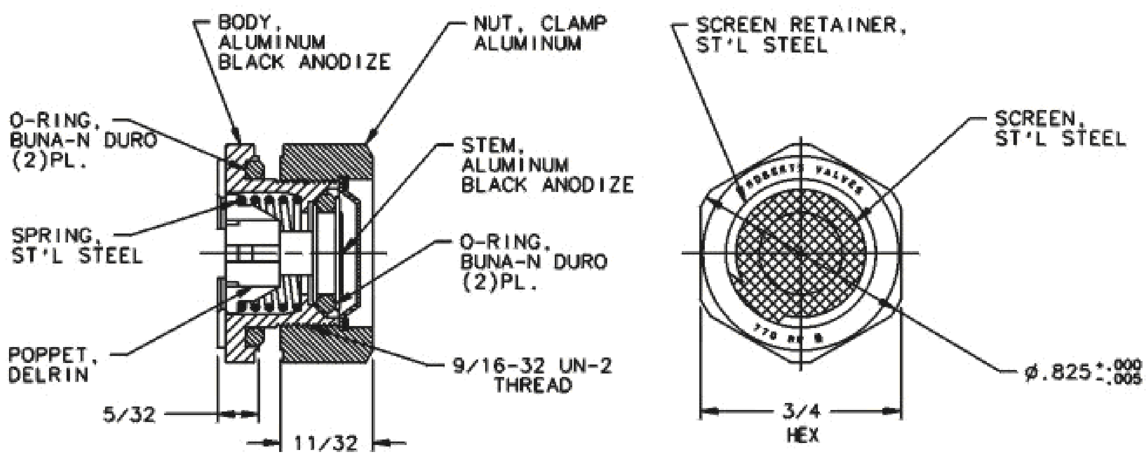

Figure 5.10-6 RICH Halkey-Roberts C770RP 1.0 (Cracking Pressure =- 1.0 psi)

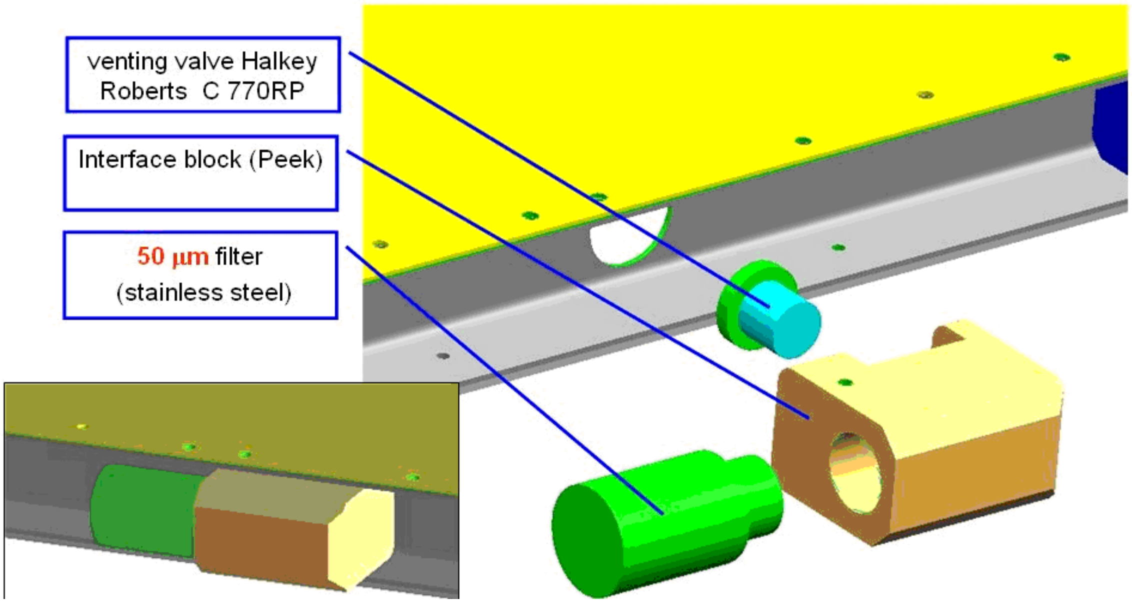

Figure 5.10-7 RICH Vent Valve and Filter Installation

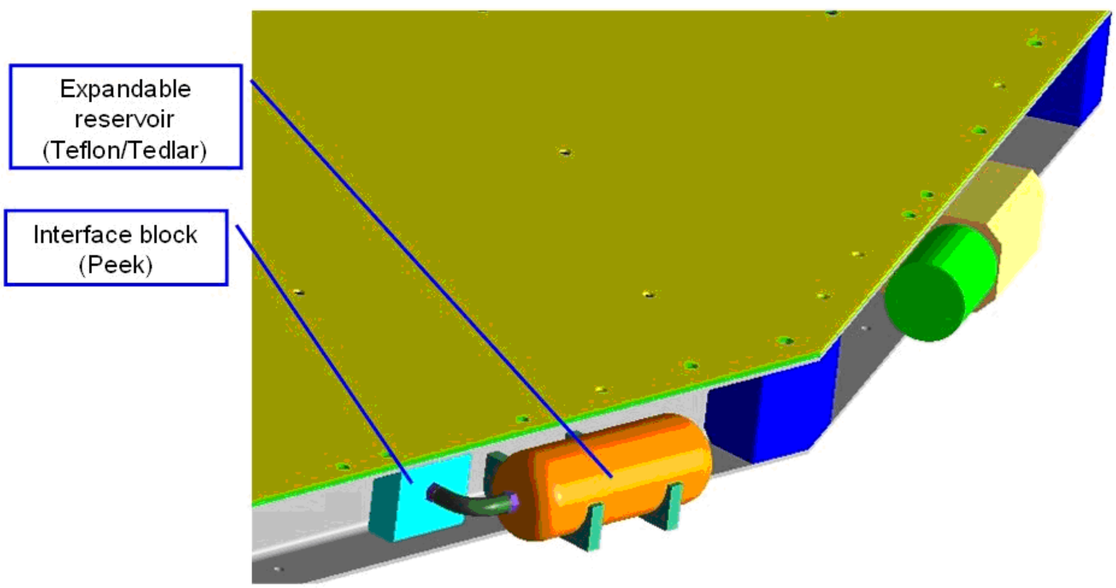

Figure 5.10-8a RICH Expandable Reservoir

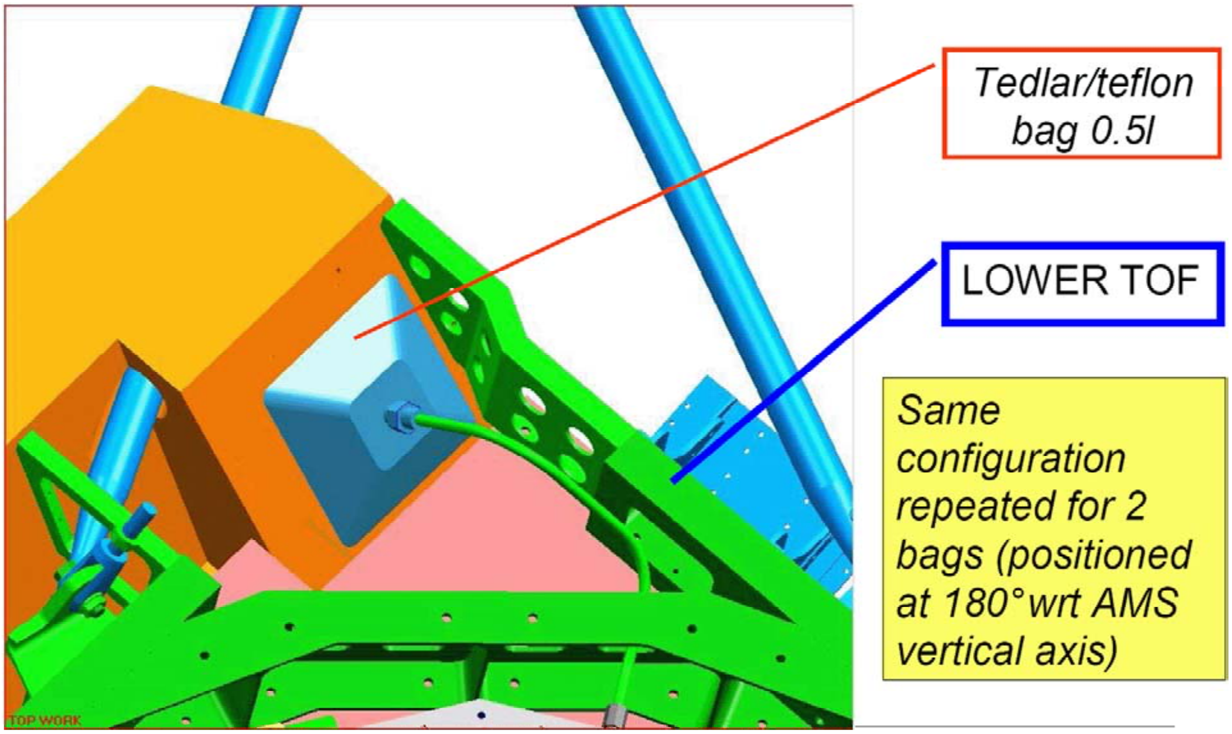

Figure 5.10-8b RICH Expandable Reservoir

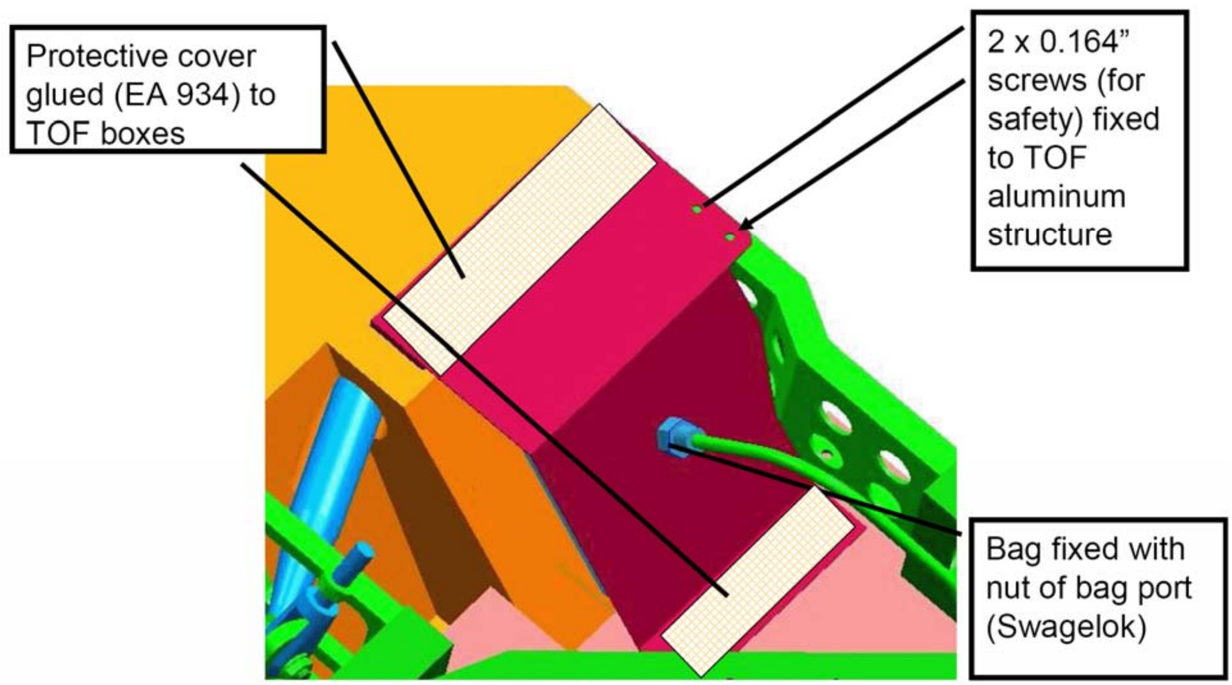

Figure 5.10-8c RICH Expandable Reservoir Cover

The second layer of the RICH is a reflector that is shaped as a truncated cone, described by a trapezoid rotated about its centroid. The interior surface of this element is a highly polished composite/metal mirror. The mirror is manufactured in three pieces (Figure 5.10-9) to be very light and have a precise, highly reflective, surface. The reflector is made of composite material with layers of deposited gold, alumina, chromium, and quartz. A debris shield consisting of eight aluminum panels surround the reflector to protect it from penetrations that would damage the mirrored surface and allow light to enter the RICH and disturb detection.

TABLE 5.10-1 RICH MIRROR COMPOSITION

Al_3O_3/TiO_3	1 mm
Epoxy Resin	400 μm
Gold	0.2 μm
Chromium	150 μm
Aluminum	0.1 μm
Quartz	0.1 μm

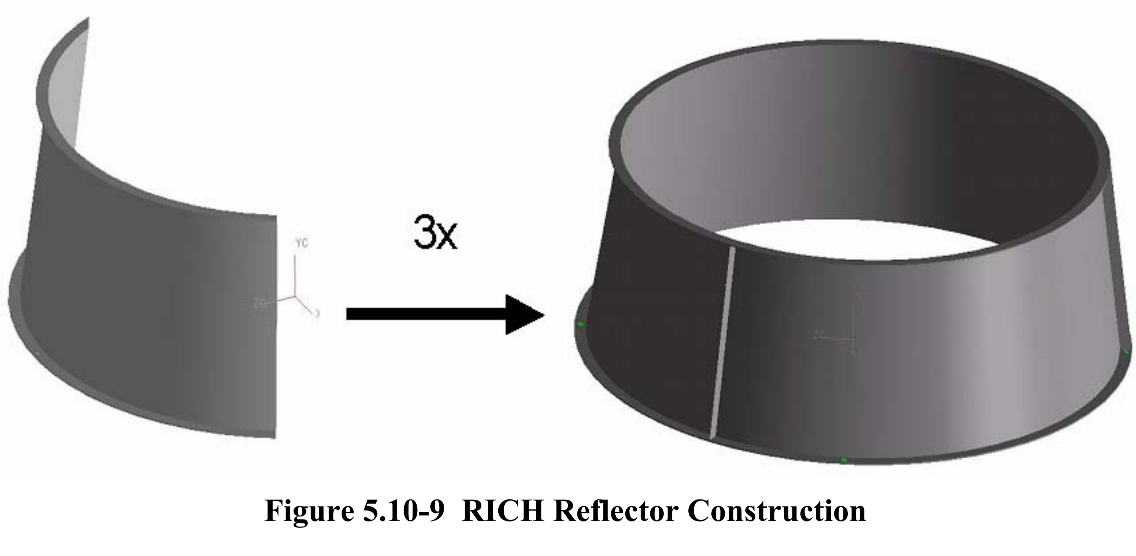

Figure 5.10-9 RICH Reflector Construction

The lower layer of the RICH construction contains the primary structure that supports the RICH and interfaces to the Lower USS-02. Within the secondary structure of the lower assembly are the rectangular and triangular arrays of photomultiplier tubes that will detect the photons from the Cerenkov radiation. Construction of the Lower RICH support structure and PMT support grids are shown in Figure 5.10-10.

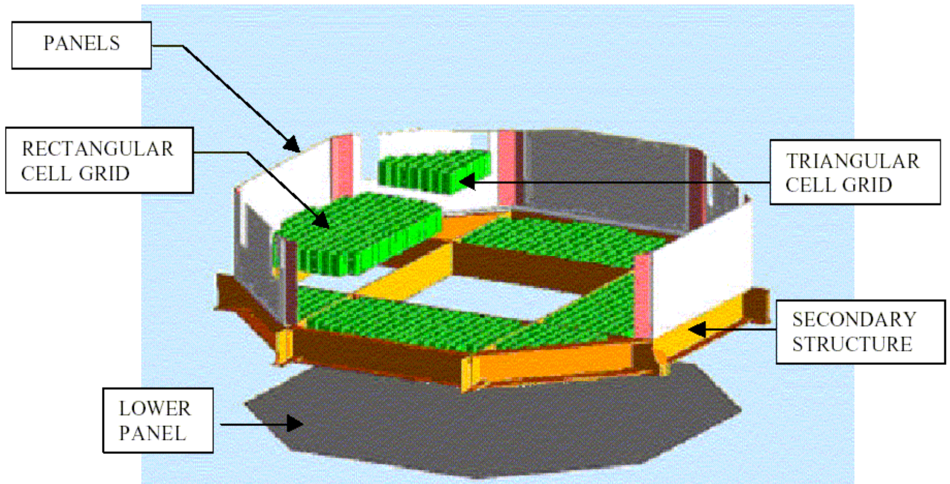

Figure 5.10-10 Lower RICH Construction

The PMTs for the RICH are constructed using Hamamatsu R7600 M16 photomultiplier tubes and a 4x4 matrix of light guides to correlate with the 4x4 photocathode grid of the photomultiplier tube. An optical pad assures the proper transmission of light into the photomultiplier tube and also seals off the glass front of the vacuum tube. The light guides are compressed into this optical pad using Nylon cords to assure good light transmissivity. The assembly of an individual PMT is shown in Figure 5.10-11.

The base of the photomultiplier tube is potted and the boards of the PMT are conformally coated to protect the electronics and to limit the coronal breakdown potential for the high voltage system. This can be seen in the upper left image of Figure 5.10-12. The welded soft iron outer body provides attenuation of the magnetic fields and support interfaces for integrating into the RICH secondary structures as shown in the lower graphic of Figure 5.10-12.

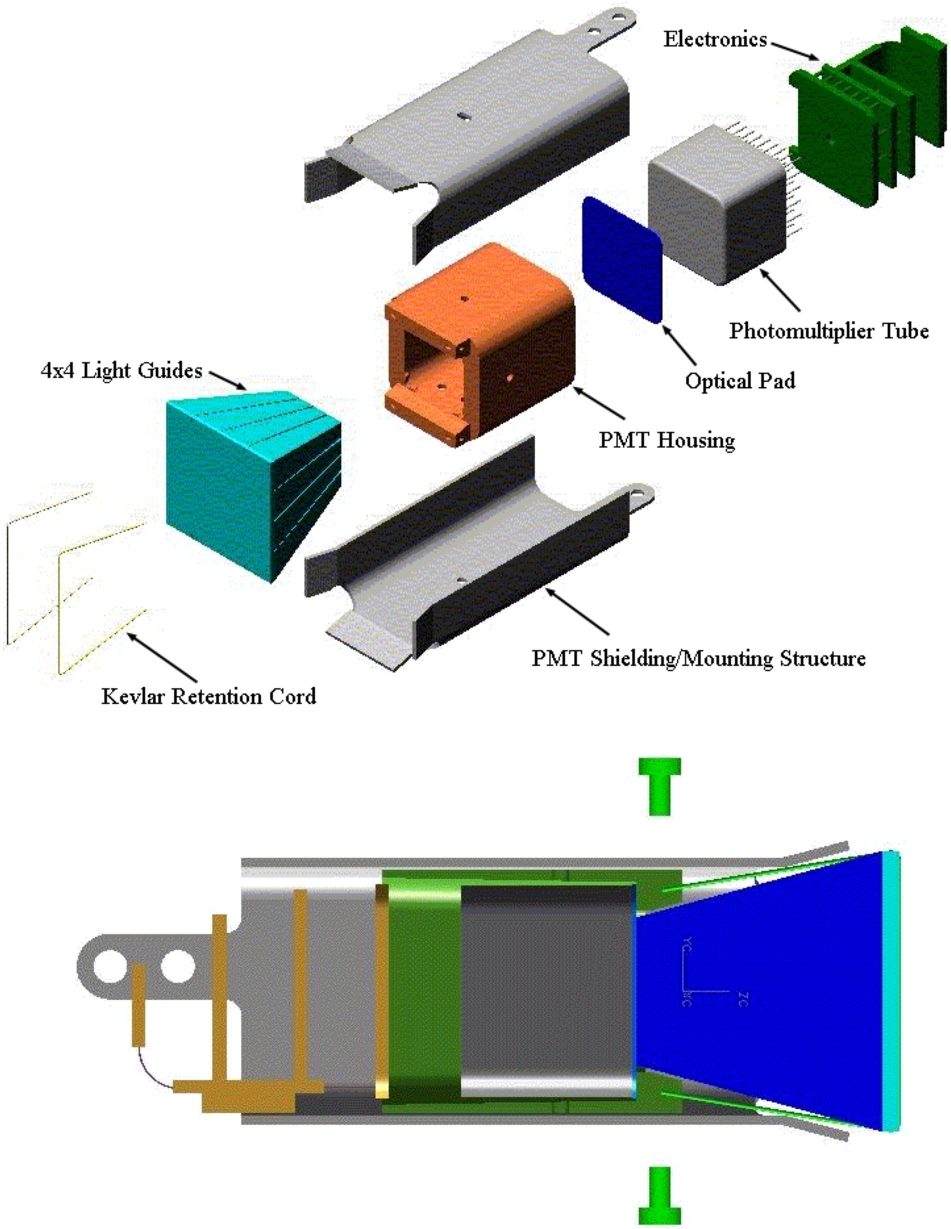

Figure 5.10-11 RICH PMT Construction (Kevlar cord replaced with Nylon wire)

The individual PMTs are mounted to the triangular and rectangular grids shown in Figure 5.10-10. The upper right image of Figure 5.10-12 shows the mounting technique used within the grids.

The RICH PMTs are powered by four RICH high voltage bricks attached to the Lower USS-02 structure. Each of these bricks generates voltages at 1000 VDC and supplies this voltage to the PMTs. The RICH high voltage bricks are fully potted as are the high voltage electronics on the PMTs. The cabling used to route this power is rated in excess of the voltages present and use high voltage connection techniques to eliminate possible sources for discharge, corona and electrical shock. Figure 5.10-13 shows the mounting locations for the high voltage bricks.

The signals from the PMTs are sent to the R Crate for data processing to establish the high energy particle or radiation incident characteristics.

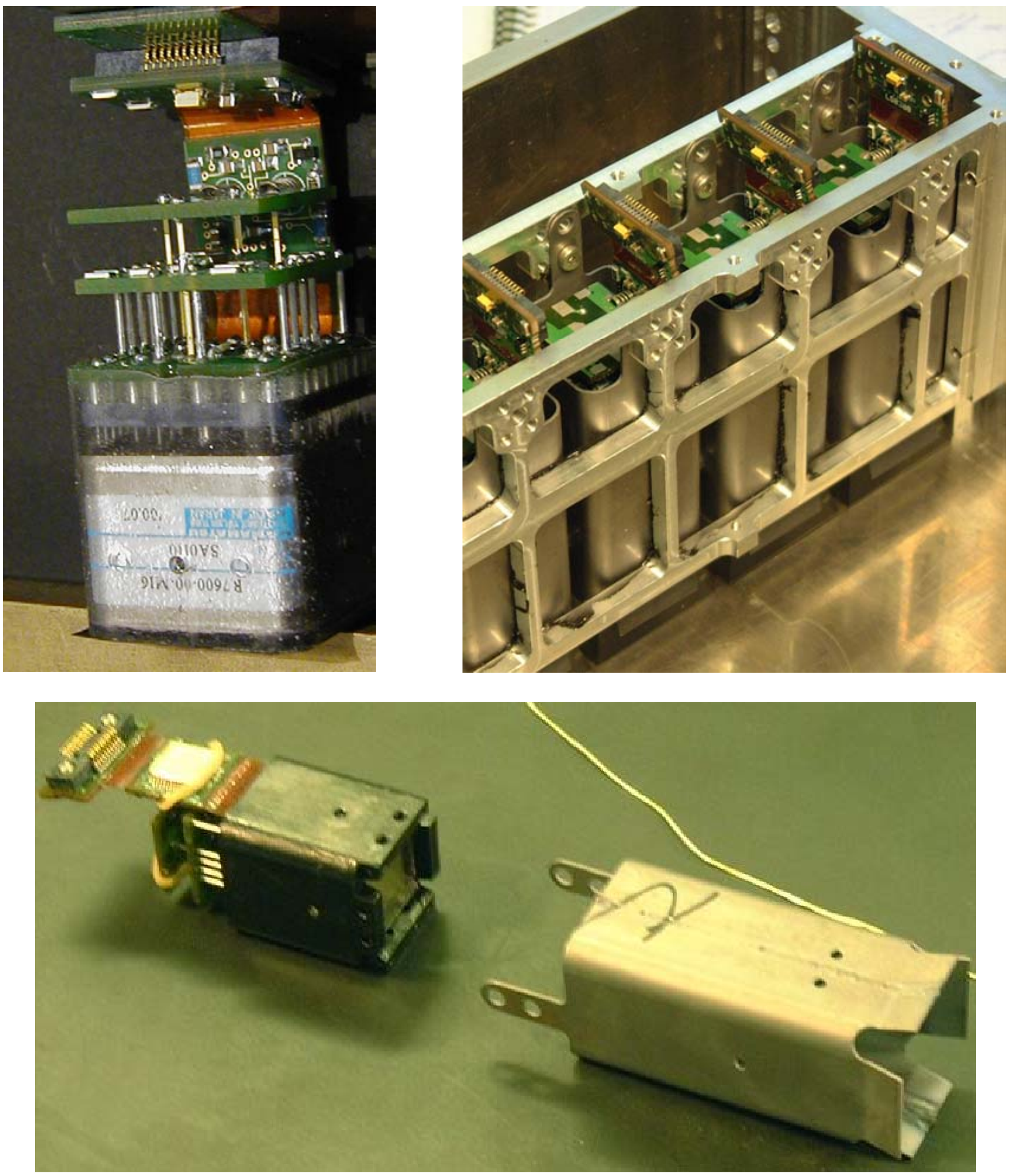

Figure 5.10-12 RICH PMT Construction and Mounting

The 406 lb (184 kg) RICH interfaces with 8 flanges on the Lower USS-02 as shown in Figure 5.10-14. Each interfaces uses 2 bolts per flange (16 total) secure the RICH to the Lower USS-02. Each of these flanges is riveted to the Lower USS-02 box beams with 24 structural rivets.

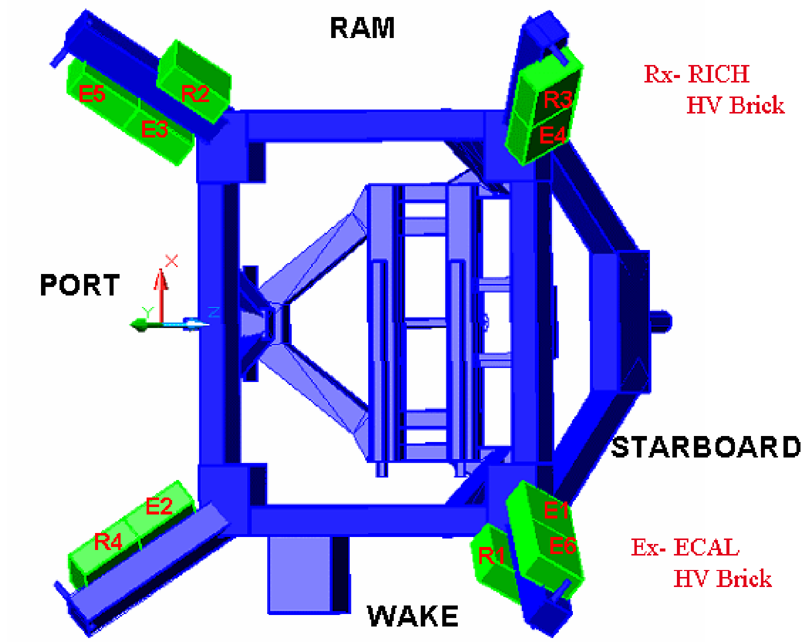

Figure 5.10-13 HV Brick Mounting for RICH and ECAL on Lower USS-02

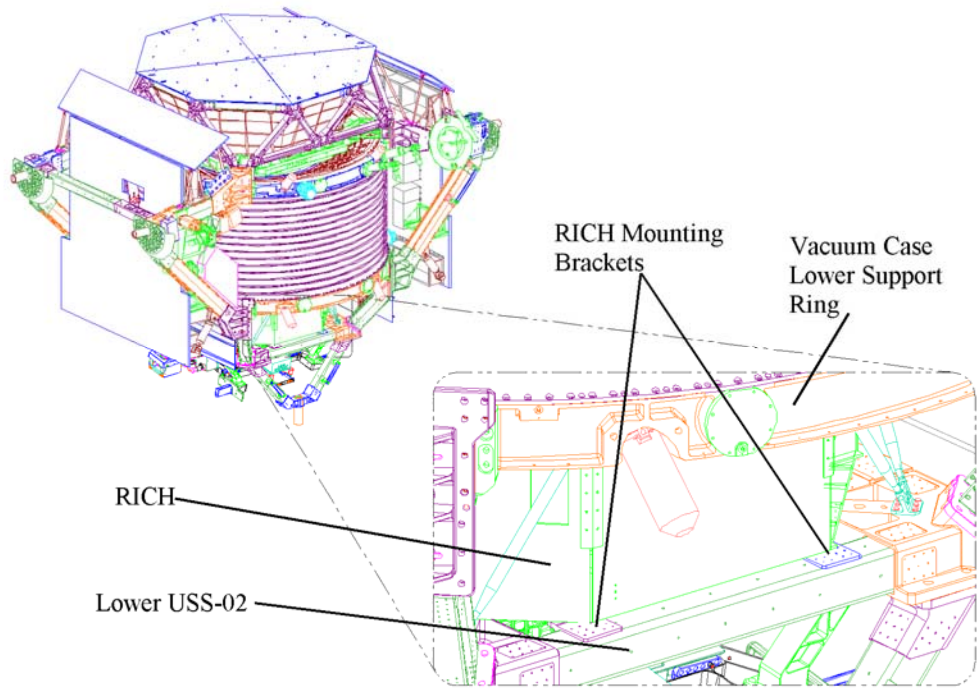

Figure 5.10-14 RICH Structural Interface